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COVID-19's impact on Australian wine markets and regions*

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This paper provides an empirical case study of impacts of COVID-19 on Australia's wine sector. Wine exports were subject to disruptions and, like domestic wine sales, were adversely affected not only by temporary declines in consumers' expected incomes but also by the social distancing measures and self-isolation that led to closure of restaurants, bars, cafes and clubs plus declines in international travel and tourism. Partly offsetting this has been a boost to off-premise and direct e-commerce sales. We first estimate those impacts and their expected partial recovery in 2021 using a new model of global beverage markets. Then, we add results on regional effects, including through domestic wine tourism, using a new economy-wide model with sub-national regions. The paper concludes by drawing lessons on how this sector's resilience to future global shocks could be strengthened.

Key words: CGE modelling, regional impacts, tourism, wine.

JEL classifications: C68, L83, R11, F14

1. Introduction

Global-scale disasters are uncommon, but by definition they are not only devastating globally but can be indiscriminate in their impacts on individual nations and their regions, firms and households. Hence it is important to learn from each event. COVID-19 is the most recent example of an unpredictable and sudden disaster hitting the world in 2020, while climate change is an example of a slower impact and possibly more-predictable global phenomenon. The rapid economic growth of China and the relative decline of power of the West, especially the United States, are not an unmitigated disaster of course, but it also has global consequences. Appropriate policy responses to all three events have been hampered by the demise, following the global financial crisis of 2007–08, of support from numerous key national governments for the multilateral system.

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This paper provides a case study of impacts on the Australian wine sector of COVID-19. The wine sector has been and continues to be impacted also by climate change (Anderson et al., 2008) including increased frequency and ferocity of drought, floods and bushfires (Wittwer, 2020). In addition, Australia's wine industry was initially harmed by—and more recently benefitted from—the rise of China and of trade policy responses to that.¹

The paper is structured as follows. The next section briefly outlines the salient features of COVID-19 as it impacts national and hence global beverage markets. Section 3 estimates those impacts using a new model of global beverage markets, focusing on their effects on Australia. Those results are only at the aggregate national level and so do not show regional impacts including through wine tourism. To capture the latter, Section 4 summarises a new economy-wide model of Australia that is disaggregated so as to capture its wine regions. As the economic impacts of COVID-19 unfold, we are able to check simulated results based on a detailed model and database with observations, particularly in national accounts data. Section 5 draws on that regionally focused national model, as well as the wine export consequences of COVID-19 from the global beverage model, to estimate various impacts on Australian wine regions of that pandemic and policy responses to it. The final section draws lessons from this case study, particularly on how this sector's resilience to future global shocks can be strengthened.

2. COVID features of relevance to wine markets

Every sector of most national economies has been affected by COVID-19, most of them adversely because of curtailed production and falling product demand following varying degrees of economic lockdown by governments, social distancing and self-isolation. Where the national decline in supply (production plus change in seller stocks) is less than the decline in demand, the difference spills over into amplified percentage changes in the volume of net exports. Globally, if the boost in supply exceeds [is less than] the change in demand for a product, its international price falls [rises].

¹ The initial harm to Australian winegrowers from China's economic rise came from the real exchange rate appreciation in the first dozen years of this century due to China's voracious demand for imports of minerals and energy raw materials and farm products (Anderson and Wittwer 2013; Anderson 2018); the subsequent benefits came from the end of that mining boom (real exchange rate reversal) and growth in China's demand for wine following its income growth and urbanisation (Anderson 2020a) and trade diversion associated with the signing of free trade agreements between China and Australia while the United States and China engaged in a bilateral trade 'war'. As of late 2020, however, Australia has been hit by the introduction of prohibitively high anti-dumping and countervailing duties on China's imports of Australian still bottled wine. This last shock is analysed by Wittwer and Anderson, 2021a but not included in the present analysis.

In the case of beverage consumption, sales to consumers are affected not only by the temporary decline in expected incomes but also by the social distancing measures and self-isolation that have led to the closure of restaurants, bars, cafes and clubs plus the decline in travel and tourism and hence also in duty-free sales, consumption on airlines and cruise ships, and visits to cellar doors. Certainly, there have been some offsetting increases in off-premise sales and, for small producers, direct e-commerce sales; and there were some increases in consumer-held stocks in anticipation of a period of self-isolation at home. Off-premise beverage sales typically tend to be lower-priced than recent on-premise purchases though. During the global financial crisis of 2008–09, the decline in both quantity and quality of sparkling wine sales was especially marked, and the subsequent rate of growth from the lower 2009 base was slower than it had been in preceding years.

Wine production, on the other hand, was initially affected relatively little by COVID-19, even in the Southern Hemisphere where the 2020 vintage timing coincided with when the coronavirus struck. This was because exemptions were made, including to labour movements, to allow the industry to complete its crush with limited supply impacts. Unlike wine, production of beer and spirits is not dependent on a perishable crop, and its production processes have not been seriously affected by social distancing measures. Hence, supply adjustments to changed market signals can be expected to be as per usual when demand patterns change, albeit with some disposal of barrelled beer after the first few weeks of on-premise closures.

3. Global beverage market modelling and Australian results

Analysis of markets for the three main alcoholic beverage groups (grape wine, beer and spirits) requires a global economic model of national beverage markets connected through international trade, in which the interactions between each nation's producers and consumers of these three beverages are explicitly recognised. Wittwer and Anderson (2020a) recently generated such a model, which is used here to provide pertinent simulation results for Australian wine trade. In turn, those results can inform our modelling of the more-detailed impact of COVID-19 on the Australian economy.

3.1 The Global Bev model

The Global Bev model is calibrated to 2016–18 data, but for present purposes it is updated to 2019 and then projected to 2020 and beyond calendar years. In an early analysis (Wittwer and Anderson, 2020b), following IMF macroeconomic growth rate projections of April 2020 which took into account expected COVID-19 impacts on GDP, a V-shaped recovery in 2021 was assumed. In the present paper, a much slower ('Nike tick') recovery is assumed that stretches beyond 2021, based on the latest (October) projections by the IMF (2020). Results are reported each year relative to a no-COVID

business-as-usual baseline simulation that reflects a medium-term global slowdown that was expected in the absence of COVID-19 (so as to avoid exaggerating the impact of the pandemic).

The assumed extent of the macroeconomic shock to aggregate household expenditure in 2020 and its subsequent partial recovery in 2021 is shown in Appendix Table S1 for 51 countries or residual country groups. The average assumed differences between the COVID and no-COVID scenarios in aggregate household expenditure globally are -7.5% in 2020 and -5.5% in 2021. For Australia, those differences are -6.2% and -5.5% .

There is of course a huge amount of uncertainty around these 'best guesses' by the IMF. In a lengthy global macro modelling article, McKibbin and Fernando (2020) reported simulations when new COVID-19 cases globally were in the thousands and recorded deaths globally were fewer than 100 daily. By December, global new cases were around 700,000 daily and deaths 10,000 to 15,000 daily.² Their early study examines seven COVID scenarios in which the aggregate household expenditure impact for Australia in 2020 ranges from 0% to -9% , for example. The IMF projections appear to be close to national forecasts of major economies at that time for 2020. What is more uncertain is how rapidly economies will recover post-2020. The latest IMF projections for 2021 imply not a perfect V pathway but rather in the shape of a Nike tick (less than full recovery in 2021 due to, for example, older stood-down workers not being re-employable). An even more-gradual return to 2019 expenditure levels than assumed here, stretching over several subsequent years, is also possible (due to, for example, consumers being slow to return to crowded places even after restrictions are lifted).

The only other modelling change made in this global scenario is that wine demand is assumed to move away from high-quality sparkling wines (fewer celebratory events) and slightly towards high-quality still wine in 2020: as a consequence of the closure of restaurants, cafes, pubs and clubs for several months, consumers were able to afford better wines to drink at home. Specifically, we assume there is a temporary 15% taste swing away from sparkling wine and a 5% swing in favour of super-premium still wine during 2020.³

In the GLOBAL-BEV model, wine markets have been disaggregated into four types, namely non-premium (including bulk), commercial-premium, and super-premium still wines, plus sparkling wine. Commercial-premium still wines are defined to be those between US\$2.50 and \$7.50 per litre pre-tax at a country's border or wholesale. Beer and spirits are not split into regular and craft categories, because the latter still have small market shares in volume terms and are minor in international trade. The world is divided into 44

² See <https://www.worldometers.info/coronavirus/>

³ One Champagne producer reported a decline of 18% in shipments in 2020 (see <https://www.thedrinksbusiness.com/2021/06/booming-champagne-could-reach-pre-covid-levels-by-year-end/>)

individual nations with all other countries being captured in seven composite residual regions. The primary sources of data for constructing the GLOBAL-BEV model's baseline database for 2016–18 are Anderson and Pinilla (2020) plus Anderson (2020b) for taxes on beverage consumption and imports, Holmes and Anderson (2017) for wine, beer and spirits average consumer expenditure data and United Nations (2019) for volume and value of international trade in beverages.

This GLOBAL-BEV model includes a linear expenditure system of household demand covering wine products, beer, spirits and a single composite of all other products in each country such that it has elements of an economy-wide model with differing income elasticities of demand for these products. Grapes are assumed to be not traded internationally, but other products are both exported and imported. All prices are expressed in real (2017) US dollar terms.

3.2 Global Bev model results for Australasia

The results for Australia of the 2020 recession due to COVID-19 and the subsequent incomplete recovery in 2021 are as follows, focusing on wine prices, consumption and trade.

3.2.1 Effects on domestic prices

The expected drops in aggregate national expenditure in 2020 are projected to lower real producer prices of beverages in all regions, but somewhat more for wine than for beer and spirits, due to the taste swing against sparkling wine (Table 1a). The fall in average prices across countries is much more for sparkling wine than for other beverages due to the taste swing.

The assumed part reversal of incomes in 2021 (Table 1b) is insufficient to make much impact in narrowing the difference between prices in the COVID and business-as-usual scenarios. This reflects the re-imposition of lockdowns and the spate of second-wave coronavirus infections in numerous countries, postponing the recovery that had initially been hoped for in late 2020.

3.2.2 Effects on consumption

The shocks given to depict COVID-19 disruptions are unusual, although the model follows usual theory. Hence, the household demand equation in GLOBAL-BEV follows the form

$$x_c - q = \varepsilon_c \cdot (C - q) + \sum_d \eta_{cd} \cdot p_c + a_c - \sum_d S_d \cdot a_d, \quad (1)$$

where in percentage changes x_c is the quantity, p_c the price and a_c the taste switch for commodity c , q population and C aggregate nominal consumption. The expenditure elasticity is ε_c and the matrix of price elasticities η_{cd} . S_d is the budget share of commodity d . Equation (1) omits regional subscripts.

Table 1 Real^a beverage producer prices, 2020 and 2021 (% relative to no-COVID baseline)

	AUS	NZL	WEur	US&Can	LatAmer	SthAfr	ROW
(a) 2020							
All wine	-7	-5	-11	-9	-9	-10	-13
NPWine	-5	-4	-6	-5	-3	-5	-6
CPWine	-8	-8	-9	-9	-8	-9	-9
SPWine	-4	-5	-5	-6	-6	-5	-5
Sparkling	-26	-26	-26	-27	-25	-27	-29
Beer	-5	-6	-7	-6	-7	-7	-5
Spirits	-6	-6	-5	-6	-6	-6	-9
(b) 2021							
All wine	-6	-7	-7	-8	-7	-7	-8
NPWine	-4	-4	-4	-5	-3	-4	-5
CPWine	-6	-6	-7	-7	-6	-7	-8
SPWine	-8	-7	-8	-9	-9	-8	-8
Sparkling	-8	-8	-7	-9	-9	-11	-10
Beer	-6	-5	-5	-6	-6	-7	-5
Spirits	-6	-6	-4	-6	-5	-6	-8

Note: In this and subsequent tables, NP is non-premium, CP is commercial premium, and SP is super-premium still wine.

Source: Authors' Global Bev model results.

^aExpressed in US dollars but in these simulations currency exchange rates are assumed not to change so these are the same as national currency changes.

The COVID impacts include several components. In equation (1), the income effect (negative, see Table S1) via the expenditure elasticity and taste impacts are the main drivers of domestic consumption. GLOBAL-BEV does not divide sales points between on-premise and off-premise consumption as in TERM-Wine (see Table 8). However, given lockdowns and social distancing impacts, on-premise consumption fell markedly in virtually all nations. Taste swings away from social activities increase the expenditure share of off-premise consumption of wine. That is, a budget constraint implies that a taste swing away from on-premise consumption is offset by a taste swing towards all other forms of consumption.

The projected changes in volumes of beverages consumed are reported in Table 2. The world is projected by the model to involve 5% less overall consumption of wine, 4% less for beer and 5% less for spirits in 2020. Within the wine group, sales of super-premium still wine consumption drop less than lower-priced wine (due to a taste swing towards consuming higher-price wines off-premise as expenditure on-premise falls markedly), but sparkling wine is projected to be down by more than a quarter compared with business-as-usual in 2020, a reflection of the widespread cancellation of large celebratory activities in 2020. With comprehensive observations by country, we could shock consumption directly: from equation (1), consumption x_c would be exogenous and taste changes a_c endogenous for beverages. Footnote 3 provides a source used to calibrate the taste shock to sparkling wine in the absence of more-detailed observations. Beverage consumption is affected in Asia almost as much as elsewhere, despite its income growth being curtailed

Table 2 Changes in volume of domestic consumption of beverages, 2020 and 2021 (% relative to no-COVID baseline)

	AUS	NZL	WEur	UK	US&Can	LatAmer	SthAfr	Asia	World
(a) 2020									
All wine	-3	-3	-7	-3	-7	-8	-2	-5	-5
NPWine	-2	-3	-4	-2	-6	-4	-2	-3	-4
CPWine	-3	-4	-5	-3	-5	-5	-1	-3	-4
SPWine	0	-2	-4	-1	-4	-3	0	0	-2
Sparkling	-13	-15	-17	-14	-18	-17	-12	-14	-15
Beer	-3	-5	-6	-3	-6	-6	-3	-4	-4
Spirits	-3	-4	-7	-4	-6	-6	-5	-4	-5
(b) 2021									
All wine	-3	-3	-4	-3	-5	-5	-1	-4	-3
NPWine	-2	-2	-2	-2	-4	-3	-1	-2	-2
CPWine	-3	-3	-3	-2	-4	-4	-1	-3	-2
SPWine	-3	-3	-3	-2	-5	-5	-1	-3	-3
SparkWine	-7	-8	-8	-7	-9	-8	-5	-7	-8
Beer	-3	-3	-3	-2	-4	-4	-2	-3	-3
Spirits	-3	-3	-4	-3	-4	-4	-3	-3	-3

Source: Authors' Global Bev model results.

less than in other regions, because Asia's income *difference* between the COVID and no-COVID scenarios is still large in percentage point terms.

Sales growth is projected to occur in 2021, but consumption is still expected to be lower than it would have been without COVID (compare Tables 2a and b). It would have been lower still had average prices not remained subdued.

The values of consumption alter considerably more than their volumes, because prices also fall and then begin to rise over the two years; and they alter more for fine (especially sparkling) wines than for commercial and non-premium still wines.⁴ For the world as a whole, the volume of all wine consumption is projected to be 5% lower in 2020 than it would have been without COVID and 4% lower in 2021, whereas real expenditure on wine is projected to be 11% lower in 2020 and still 8% lower in 2021. For sparkling wine globally, the differences are even starker. Beer and spirits expenditures globally are projected to fall less than for wine (Table 3).

OIV (2021) reports a 3% decrease in wine consumption in 2020 relative to 2019. Table 2 shows a decrease in wine consumption in 2020 relative to base of 5%. Therefore, the modelled impact is consistent with a business-as-usual wine consumption growth in 2020 of 2%. The global trend over the past few decades has been towards declining per capita wine consumption in traditional wine-consuming countries, combined with a slow decline in the global volume consumed. However, this masks a movement towards consumption of higher quality wine, which has resulted in the value of wine

⁴ Although price adjustments during a COVID-19 induced recession are small relative to quantity adjustments, anecdotal evidence indicates that some wineries have resorted to fire sales to maintain turnover. Discounts from direct winery sales are not recorded in retail surveys.

Table 3 Changes in real value^a of domestic consumption of beverages, 2020 and 2021 (% relative to no-COVID baseline)

	AUS	NZL	WEur	US&Can	LatAm	SthAfr	Asia	World
(a) 2020								
All wine	-8	-7	-14	-8	-12	-14	-8	-11
NPWine	-6	-6	-8	-5	-7	-7	-5	-7
CPWine	-8	-10	-11	-8	-10	-10	-7	-10
SPWine	-4	-5	-7	-4	-8	-7	-4	-5
Sparkling	-25	-26	-29	-25	-29	-29	-24	-27
Beer	-7	-9	-10	-8	-10	-10	-6	-8
Spirits	-8	-9	-9	-8	-10	-10	-10	-9
(b) 2021								
All wine	-8	-8	-9	-8	-9	-10	-6	-8
NPWine	-5	-5	-5	-4	-5	-6	-4	-5
CPWine	-7	-7	-7	-6	-7	-8	-5	-7
SPWine	-8	-8	-8	-8	-11	-10	-7	-8
Sparkling	-13	-13	-13	-12	-15	-16	-11	-13
Beer	-7	-7	-6	-6	-8	-8	-5	-6
Spirits	-7	-7	-6	-6	-8	-8	-8	-7

Source: Authors' Global Bev model results.

^aExpressed in US dollars but in these simulations both exchange rates and overall national CPIs are assumed not to change so these are the same as nominal national currency changes.

consumption growing (Anderson & Pinilla, 2021). The expenditure share-weighted volume of all wine types consumed has risen as the unweighted volume has decreased.

The actual impacts for 2021 depend much on the speed of recovery. Many countries have had periodic lockdowns in response to new COVID outbreaks. Each lockdown moves consumption away from social activities. In the context of beverages, off-premise consumption remains below base due to lockdowns. Continuing disruptions to international tourism will keep the component of sales depending on this form of tourism (see Table 8) below base. The duration of lockdowns, with their marked impact on the composition of household consumption, is the key driver of impacts reported in this study.

3.2.3 Effects on international trade

The volumes of world trade in the various wine categories alter by percentages slightly smaller in size to those for the volume of global consumption, but their values alter by somewhat larger percentages than changes in consumer expenditure because of the changes also in unit values of traded wines. In particular, the value of wine exports is smaller by three times as much as their volume in both 2020 and 2021 (Tables 4 and 5). Australia and New Zealand are affected a little less adversely than other exporters of wine, but still harmed. Their exports are hurt less because sparkling wine is a smaller share of their exports than of the rest of the world's and that is the wine type hit hardest by the COVID lockdowns.

Table 4 Changes in volume of wine exports, 2020 and 2021 (% , relative to no-COVID baseline)

	AUS	NZL	WEur	US&Can	LatAmer	SthAfr	World
(a) 2020							
All wine	-3	-2	-3	-2	-7	-2	-4
NPWine	-4	-3	-1	-2	-6	-3	-2
CPWine	-3	-1	-1	0	-8	-1	-2
SPWine	-3	-1	0	-3	-6	-1	0
Sparkling	-17	-12	-15	-15	-29	-11	-15
(b) 2021							
All wine	-1	-1	-3	2	-6	-1	-2
NPWine	-2	-1	-1	0	-4	-2	-1
CPWine	-1	-1	-1	3	-5	0	-1
SPWine	1	-1	-1	2	-10	-2	-1
Sparkling	-4	-2	-8	-1	-10	5	-8

Source: Authors' Global Bev model results.

Table 5 Changes in real^a value of wine exports, 2019 to 2021 (% , relative to no-COVID baseline)

	AUS	NZL	WEur	US&Can	LatAmer	SthAfr	WORLD
(a) 2020							
All wine	-11	-7	-13	-9	-13	-10	-12
NPWine	-9	-7	-7	-8	-10	-9	-8
CPWine	-11	-13	-11	-10	-15	-11	-11
SPWine	-7	-7	-5	-8	-10	-7	-6
Sparkling	-34	-29	-32	-32	-39	-29	-32
(b) 2021							
All wine	-8	-9	-10	-7	-12	-8	-10
NPWine	-7	-5	-5	-5	-8	-7	-6
CPWine	-8	-9	-8	-6	-11	-7	-8
SPWine	-8	-10	-10	-8	-16	-10	-10
Sparkling	-13	-11	-16	-11	-16	-6	-16

Source: Authors' Global Bev model results.

^aExpressed in US dollars but in these simulations both exchange rates and overall national CPIs are assumed not to change so these are the same as nominal national currency changes.

World imports change to the same extent as world exports of course. Table 6 shows that wine imports in 2020 are projected to be lower in Western Europe and North America by more than twice as much in percentage value as in percentage volume terms. In Asia, the value to volume difference is even greater, because a relatively high share of Asia's imports are fine wines, and their prices have risen relative to those of commercial wines.

3.2.4 Caveats

As mentioned at the outset, results depend especially heavily on our assumptions about the extent to which economies go into recession in 2020 and the extent and speed of recovery in the years to follow. The V-shaped projection in April 2020 by the IMF, implying a near-return to 2019 incomes

Table 6 Changes in volume and real^a value of wine imports, 2019 to 2021 (% , relative to no-COVID baseline)

	Volume					Real ^a value			
	WE	US&Ca	Asia	World		WE	US&Ca	Asia	World
(a) 2020									
All wine	-5	-2	-1	-4	All wine	-14	-10	-10	-12
NPWine	-2	-1	-1	-2	NPWine	-8	-6	-7	-8
CPWine	-3	-1	1	-2	CPWine	-13	-9	-9	-11
SPWine	-1	0	0	0	SPWine	-7	-5	-6	-6
Sparkling	-15	-12	-11	-15	Sparkling	-33	-30	-30	-32
(b) 2021									
All wine	-2	-2	-1	-2	All wine	-10	-10	-9	-10
NPWine	-1	-1	0	-1	NPWine	-6	-5	-5	-6
CPWine	-1	-1	1	-1	CPWine	-8	-7	-6	-8
SPWine	-1	-1	-1	-1	SPWine	-9	-9	-10	-10
Sparkling	-7	-8	-6	-8	Sparkling	-15	-16	-14	-16

Source: Authors' Global Bev model results.

^aExpressed in US dollars but in these simulations both exchange rates and overall national CPIs are assumed not to change so these are the same as nominal national currency changes.

by 2021, was more optimistic than many commentators suggested at the time and also than the IMF's October 2020 projections. Rather than our assumed Nike tick-type recovery, the trajectory could be more U-shaped instead, delaying the return to growth by one or more years. The International Wine and Spirits Research group, for example, projects it will take five years for global alcohol consumption to return to 2019 levels after the slump of 2020, and possibly even longer in the UK and US.

The immediate impact also depends on 2020 winegrape crush and wine production. Australia's, 2020 crush turned out to be 13% below the 'normal' volume we have assumed. And given the current excess supply of wine in the United States and EU, much of Europe's 2020 vintage may be diverted to distillation by the end of 2020. This would lessen the downward pressure on wine prices globally in that and the next year, but means lower returns to grapegrowers in 2020.

The projected impact of COVID in 2021 also depends on our assumed return to premiumisation on the part of consumers (a reversal of our assumed taste swing away from sparkling wine in 2020), which is based on the assumption that consumers will return fully to eating out, pubbing, clubbing and cellar-door visiting in 2021. Again that may be too optimistic, at least in terms of start date and speed if not also on the eventual extent of recovery.

Also assumed throughout is that beverage-specific national policies affecting production, consumption and trade are unchanged. Yet several are already in train or being contemplated. Numerous bilateral preferential trade agreements (PTAs) following Brexit are expected to be negotiated from the end of 2020 and are likely to have non-trivial effects on wine trade (Anderson & Wittwer, 2018). And China has imposed temporary tariffs of

between 113% and 218% on bottled still wine imported from Australia, pending dumping and subsidy enquiries that are expected to be completed in August 2021, at which time similar-sized anti-dumping and countervail duties may apply for a further five years.

A Global Bev model simulation of those new Chinese tariffs suggests their magnitude is sufficient to wipe out Australian exports of wine to China, a sales loss of US\$690 million per year (Wittwer and Anderson 2021a, 2021b). While that will be partly offset by greater sales to other export markets and to Australia's domestic market (partly by crowding out some imports into that market), Australia's global exports are projected to be depressed by about one-sixth (\$420 million) and producer prices by one-twelfth.

4. Economy-wide modelling of Australian wine regions and results

To go deeper than the above national modelling of wine markets, and in particular to examine the impacts on regions within Australia of COVID-19 restrictions on different domestic sales points for wine and on different States' regions, we use a new CGE model of the Australian economy called TERM-Wine.

4.1 Outline of the TERM-Wine model and base assumptions

TERM-Wine is a multi-regional computable general equilibrium (CGE) model that represents three grape and three wine types: non-premium *NPwine*, commercial-premium *CPwine* and super-premium (including sparkling) *SPwine*. It is based on official data for the 2015–16 financial year and is projected forward to provide a baseline for each financial year over the following ten assuming no COVID. As with the Global Bev model, we then compare the alternative COVID simulation each financial year with that business-as-usual baseline scenario. It does not align perfectly with the Global Bev model (financial vs calendar years, no separate sparkling wine), but the export results from the latter are nonetheless used to calibrate the shock to wine exports in TERM-Wine.

The master database of the model includes 195 sectors and 334 regions (SA3 level) but, since it is not computationally possible to run such a large database in the full dimensions, a tailored aggregation is prepared for each study. In the sectoral dimension of this application, the aggregation has 28 sectors, including three grape and three wine types, and other sectors relevant to the industry. In the regional dimension, TERM-Wine is aggregated to 16 regions as shown in Figure S1. Sectors include *HotelsCafes* (restaurants, bars, cafes, hotels, clubs), *Tourism* (domestic tourism by citizens) and *ExpTourism* (inbound tourism by foreigners), drawing on Wittwer (2017). Each of these sectors includes wine inputs, so that downturns or booms in demand in these sectors result in changes in demand for wine and hence winegrapes. Since TERM-Wine includes both off-premise (direct consumption by households)

and on-premise (restaurants, bars, cafes, hotels) consumption, the impacts of altered consumption patterns may be in opposite directions for the two forms of consumption. Reductions in dining out and travelling will have a negative effect on on-premise consumption and a positive effect on off-premise consumption of wine.

4.2 Shocks to depict the short-run effects of COVID-19

Table 7 shows our assumptions concerning direct COVID-19 impacts by quarter and annually. For the present study, concentrating on the grape and wine sectors, we run TERM-Wine using annual time intervals, shocks to which are based on estimated direct quarterly impacts. Given that Victoria had a second lockdown in the latter half of 2020, we assume that recovery in Victoria lags the rest of Australia by a quarter. "Social sectors" in TERM-Wine refer to services that are non-essential. The group includes *HotelsCafes*, *Transport* and *OthService* (other services).

In the present study, from equation (1), the main household demand shocks are taste shocks (a_c) as shown in Table 7, reflecting social restrictions and lockdowns.

Lockdowns and social distancing restrictions have uneven impacts on effective demands. Restaurants, for example, by being restricted to take-aways, either close down or reduce turnover by two-thirds or more. Since consumers cannot dine out, we impose a taste swing against *HotelsCafes* and other activities that entail social interaction. ABS national accounts (catalogue 5206.0) indicate reasonable alignment between Table 7 and observations up until the March 2021 quarter, notably for *HotelsCafes* value-added. Indeed, if household expenditure data were also available, we could impose *ex post* quantity shocks directly, making temporary taste shifts endogenous.

Fiscal responses to alleviate the economic slump arising from the pandemic in theory reduce the negative impact of the slump on aggregate consumption (C in equation 1). However, with limited opportunities to spend, households increased savings in 2020.⁵ Aggregate consumption fell 3% in 2019–20 from the previous year and in the nine months ending March 2021 remained 2.5% below 2018–19 levels. The modelled impact was a decline to 3.9% below base in 2019–20 and 4.9% below base in 2020–21, which align reasonably with observations after accounting for expected growth in the absence of the pandemic (Figure 3).

During lockdown which lasts for several months, tourism (domestic and imported *Tourism*) and *ExpTourism* activities virtually cease. Domestic tourism recovers first, with a slower recovery over several years for *Foreign*

⁵ See <https://www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-national-income-expenditure-and-product/latest-release#data-download>.

Table 7 Timeline of demand and supply indexes imposed on TERM-Wine for Australia, 2020 to 2022 by quarter-years (base=100)

	2020q1	2020q2	2020q3	2020q4	2021q1	2021q2	2019–20	2020–21	2021–22	2022–23
“Social sectors” tastes										
Vic	100	30	30	70	85	95	82.5	70	100	100
RoAust	100	30	70	85	95	100	82.5	87.5	100	100
Tourism	100	30	70	85	95	100	82.5	87.5	100	100
Foreign holidays	100	5	5	5	25	50	76.25	21.25	70	90
International demand										
Mining	100	95	95	95	95	95	98.75	95	100	100
NPWine	100	97	97.5	97.5	97.5	97.5	98.5	97.5	98.9	100
CP/SPWine	100	98	98.5	98.5	98.5	98.5	99	98.5	99	100
Other	100	90	90	90	90	90	97.5	90	95	100
Tourism	70	5	5	5	25	50	68.75	21.25	80	90
Education exports	80	80	70	70	60	60	80	65	75	85
Labour supply										
Melbourne	100	85	85	89	95	97	96.2	91.5	97.4	97.8
Sydney	100	85	90	95	97	97	96.2	94.8	97.5	97.5
RoAust	100	85	90	95	97	97	96.2	94.8	97.8	98.9
Labour productivity										
Services/horticulture	100	95	95	95	95	95	98.75	95	100	100
Broadacre	100	100	100	100	100	100	100	100	100	100
Wine/manufactures	100	97.4	97.4	97.4	97.4	97.4	99.4	97.4	100	100

Sources: Authors' judgments; Hurley (2020).

holidays by local citizens and *ExpTourism* by foreigners.⁶ A temporary preference swing is imposed towards domestic and away from imported *Tourism* to depict the virtual cessation of overseas travel part way through 2019–20 and into 2020–21.

Education exports slowly worsen relative to base. This is because many international students study remotely after the international travel restrictions take effect (Hurley, 2020). The gradual worsening of education exports relative to base arises because enrolments of new international students slow. Existing enrollees may continue their course remotely, which means that universities still earn some international fee income. Education export demands cannot recover prior to the removal of international travel restrictions, although there are some early efforts to resume foreign students arriving in South Australia and the Northern Territory. Table 7 indicates only a partial recovery by 2022–23. In the simulation, education export demand is assumed to increase by 4% in each of 2023–24 to 2025–26 and then remain at this level, which is around 4% below the no-COVID baseline. The context for this is that education exports grew rapidly in the decade preceding the pandemic. Even with travel restrictions fully removed, potential international students may have a lingering aversion to travel, which may be reinforced by attitudes expressed by foreign governments.

Export demands also fall temporarily for commodities, including wine as indicated in the previous section. In the case of mining, wine and other exported items with exceptional shares going to China, the demand fall is smaller due to China's relatively quick recovery from COVID-19 lockdown.

Travel restrictions over three years will reduce Australia's population too. Net immigration was equal to 0.95% of the total population in 2019 and approached 1.3% in Victoria.⁷ The impact of travel restrictions is treated as a population fall relative to base for three years. This implies that even with a resumption of immigration, the national population and labour supply is more than 2% below a no-COVID base in 2021–22 and thereafter.

Lockdowns and restrictions on activity and travel impact on capital utilisation by sector. In the present study, capital utilisation is lowered exogenously in 2019–20 in socially restricted service sectors in the first half of 2020. The annualised shocks amount to 7% reductions in utilisation in *HotelsCafes*, *Transport* and *OthServices*. Reductions of 2.8% are imposed on *Childcare*, *Construction*, *Trade* and *Education*. In 2021–22, full utilisation is assumed to be restored.

We impose labour productivity declines on all industries other than broadacre agriculture, to reflect the impact on labour of complying with hygiene guidelines. There may be substantial productivity losses in sectors,

⁶ *Foreign holidays* in TERM-Wine is a sector distinct from *Tourism*, although the value of imports of *Tourism* is set equal to *Foreign holidays*. This captures substitutability between domestic and imported *Tourism*. *Foreign holidays* includes some domestically sourced air travel, but all other inputs are imported (Wittwer 2017).

⁷ See http://stat.data.abs.gov.au/Index.aspx?DataSetCode=ABS_ERP_COMP_SA

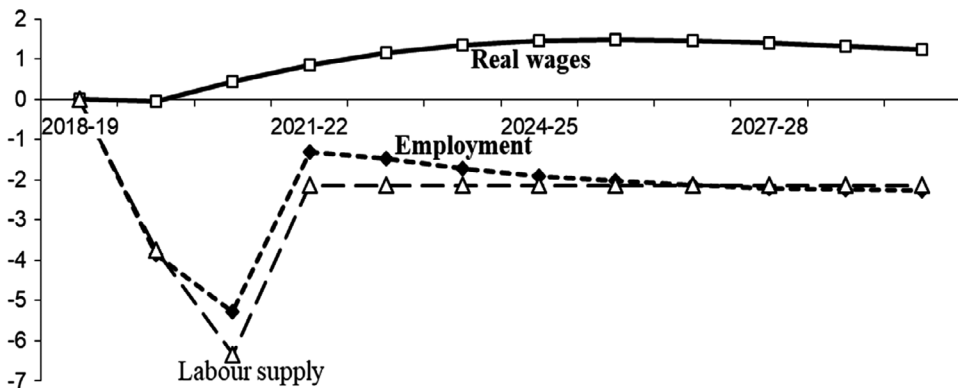


Figure 1 COVID impact on the Australian labour market (% deviation from base).
Source: Authors' TERM-Wine model results.

notably horticulture, relying on foreign seasonal workers on temporary work visas. The manufacturing sectors have only half the temporary productivity losses of the service and horticulture sectors.

4.3 TERM-Wine model's macroeconomic results

The national labour supply drops relative to base in 2019–20 and further again in 2020–21 (Figure 1). The lockdown effects were in place in the final quarter for 2019–20. Even if they are less severe in 2020–21, the effects continue for more months in the 2020–21 financial year. There are two elements to the fall in labour supply. The first is the impact of furloughed workers on effective labour supply. The second is due to international travel restrictions slowing net immigration. Employment tracks labour supply from 2021–22 but, since it falls by less than the number of workers, real wages rise by more than 1% relative to base.

We can check Figure 1 against ABS data on hours of employment (ABS catalogue 6291.0.55.001). In 2019–20, observed hours were 1.8% lower than in 2018–19. The average hours worked from July 2020 to April 2021 were 3% lower than in 2018–19. Given that baseline employment growth has been around 1% per annum due to immigration, the modelled impacts of employment being 3.9% below base in 2019–20 and 5.3% below base in 2020–21 are relatively close to observations. Jobkeeper payments, not included in the modelling, alleviated job losses.⁸

Real GDP falls sharply below base in both 2019–20 and 2020–21 (Figure 2). In 2019–20, most losses occur in the final quarter: a 4.2% decrease in real GDP annually indicates a quarterly fall of around 17%. Figure 2 depicts real GDP as the share-weighted sum of the primary factor contributions (capital and employment) net of technological change. Since

⁸ See <https://treasury.gov.au/coronavirus/jobkeeper>

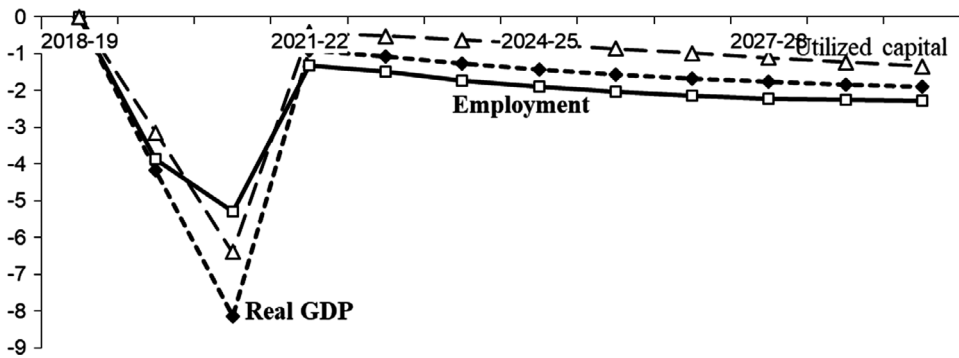


Figure 2 COVID impact on the Australian real GDP, income-side (% deviation from base). Source: Authors' TERM-Wine model results.

the percentage fall in real GDP is larger than either the percentage fall in utilised capital or in employment, there must be a negative contribution from productivity (technological change) in 2019–20 and 2020–21. This reflects the labour productivity losses imposed on most sectors to reflect compliance with restrictions in response to COVID-19.

Figure 3 shows that national real consumption and investment both fall relative to base in 2019–20 and 2020–21, reflecting the fall in national income and hence expenditure. The balance of trade worsens in 2019–20 and 2020–21 relative to base.⁹ The results suggest the taste swing away from spending associated with social activities has greater impacts on wine sectors than expenditure effects. We assume a recovery in 2021–22 except in sectors concerning international travel. With labour supply persisting below base due to lost years of net immigration relative to base, real consumption persists below base. Since real consumption is closer to base than national labour supply (which follows population within the model) from 2021 to 2022 onwards (Figures 1 and 3), there is an increase in real consumption per capita in the recovery period.

If the ratio of real wages to rates of return on capital were unchanged, capital and labour would move together. Figure 2 shows that capital stocks are not as far below base as employment in recovery years. To explain this, we use the relationship between factor rentals and factor ratios:

$$w/r = f(K/L) \tag{2}$$

where w is the real wage (deflated by the price of GDP) and r the rate of return on capital, K is aggregate capital stocks, and L is aggregate employment. The real wage rises as national labour supply falls relative to

⁹ TERM-Wine does not distinguish between public and private borrowing. Observed government deficits in response to the pandemic are large relative to observed increased household savings.

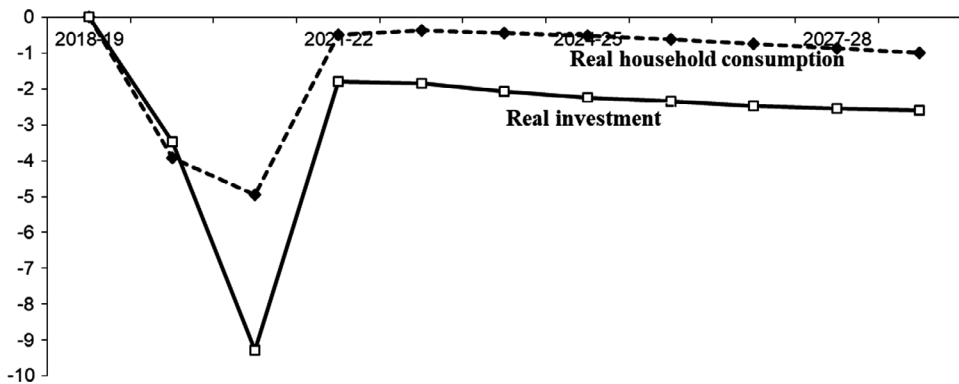


Figure 3 COVID impact on Australian real consumption and investment (% deviation from base).

Source: Authors' TERM-Wine model results.

base. We assume that capital rentals, determined globally, are unchanged. There, w/r rises, so that (K/L) must also rise. Consequently, capital moves less below base than employment.

4.4 TERM-Wine model's results for the Australian wine sector

We now examine the impacts of COVID-19 on sectors related to the Australian wine sector over time. Table 8 shows the pre-COVID breakdown between intermediate users (*HotelsCafes*, *Tourism* and *ExpTourism*) and final users, namely households and exports. The share of non-premium wine sold to *HotelsCafes* is smaller than the corresponding shares for the other two wine types: a larger share of super-premium wine is sold to households and a smaller share of super-premium wine is exported.

With restrictions enforced in response to COVID-19, we expect off-premise consumption of wine to increase. Since there is a slowdown in consumption of *HotelCafes* and domestic tourism (Figure 4), there is an accompanying slowdown in sales of wines to these domestic users.

Until the COVID-19 crisis, export values had grown steadily since 2015, by around 10% per annum, as a depreciating dollar that followed the end of the

Table 8 Sales of Australian wine by destination, 2019–20 base (using value shares at producer prices)

	NPWine	CPWine	SPWine	All wine
HotelsCafes	4.7	14.3	11.6	11.2
Tourism	10.4	16.5	7.5	11.7
ExpTourism	3.3	5.2	2.4	3.7
Households	18.0	36.2	43.0	35.2
Exports	60.7	23.4	31.7	34.4
Other	3.0	4.3	3.8	3.9
Total	100.0	100.0	100.0	100.0

Source: Wine Australia; ABS National Accounts; ABS *Tourism Satellite Accounts*.

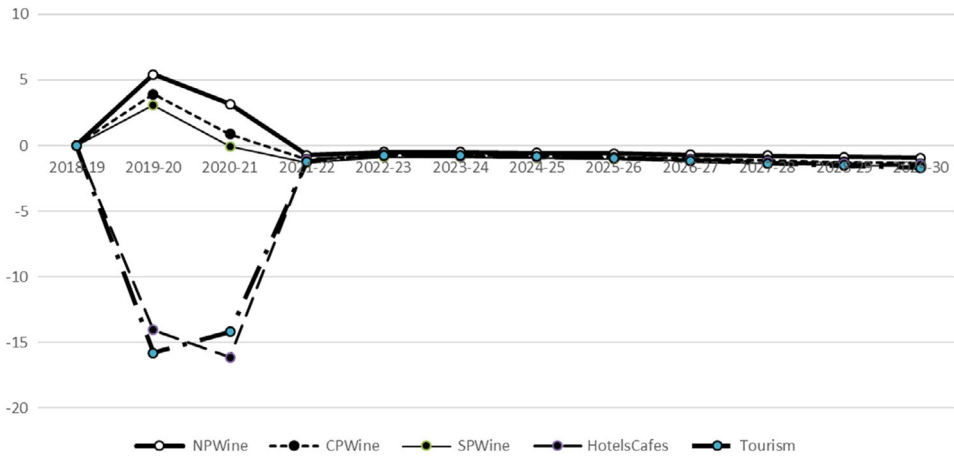


Figure 4 COVID impact on Australian household consumption of wine, dining out and tourism (% deviation from base). Source: Authors' TERM-Wine model results. [Colour figure can be viewed at wileyonlinelibrary.com]

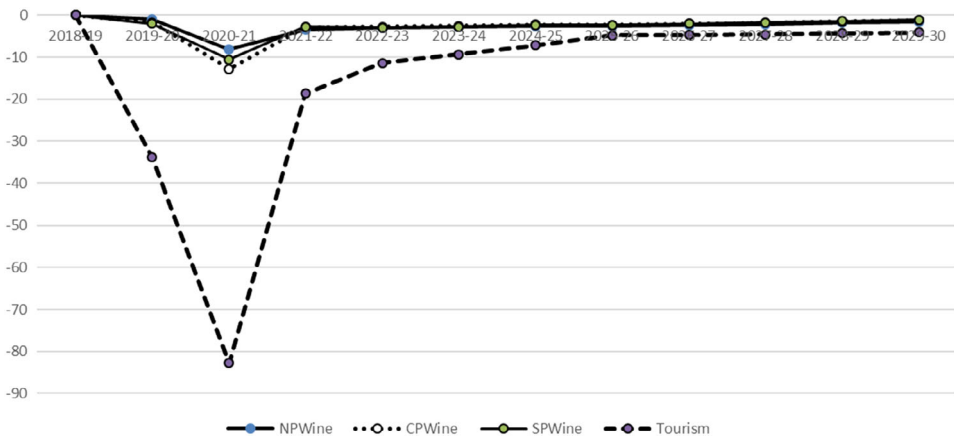


Figure 5 COVID impact on the volume of Australian exports of wine and tourism (% deviation from base). Source: Authors' TERM-Wine model results. [Colour figure can be viewed at wileyonlinelibrary.com]

mining boom improved the industry's competitiveness (Wine Australia, 2020, p. 13). The deviation in wine exports shown in Figure 5 is from a base of ongoing export growth.¹⁰ Tourism exports recover mostly but not completely by 2025–26. Given these contributions, wine sales may not recover fully in the next few years relative to a no-COVID base.

¹⁰ These results were generated just prior to China's imposition from late November 2020 of prohibitively high tariffs on imports of Australian bottled wine (discussed above at the end of Section 3).

Table 9 Back-of-the-envelope impact of COVID on national sales, Australia, 2020–21 (% contribution to total sales deviation)

	NPWine (1)	CPWine (2)	SPWine (3)	NPWine (4)	CPWine (5)	SPWine (6)	AllWine (7)
	% domestic deviation from business-as-usual (BAU)			Percentage point contribution to sales deviation			
(1) HotelsCafes	-15.6	-15.6	-15.6	-0.7	-2.2	-1.8	-1.8
(2) Tourism	4.8	4.8	4.8	0.5	0.8	0.4	0.6
(3) ExpTourism	-82.7	-82.7	-82.7	-2.7	-4.3	-2.0	-3.1
(4) Households	7.4	3.1	2.3	1.3	1.1	1.0	2.6
(5) Exports	-8.1	-12.8	-10.6	-4.9	-3.0	-3.4	-3.8
(6) Other	-8.1	-8.1	-8.1	-0.2	-0.4	-0.3	-0.3
(7) BoTE %				-6.8	-8.0	-6.1	-5.8
(8) Modelled %				-6.4	-8.1	-6.0	-5.6

Source: Authors' TERM-Wine model results.

The theory of TERM-Wine includes market-clearing equations without an avenue for adjustment via inventories. Therefore, the COVID-induced downturn reduces sales which in turn reduces output by the same total percentage. A small contribution to early industry output losses arises from temporary labour productivity losses. On this basis, we can infer the contributions to percentage changes in wine sales and output by sales point, extending the calculations beyond the export contributions above. The estimated shares shown in Table 8 are based on the ABS input–output table for wine inputs into the *HotelsCafes* sector, domestic wine consumption and exports, and ABS Tourism Satellite Accounts.¹¹ Table 9 uses a back-of-the-envelope (BoTE) approach to calculate the contribution of each sales point to 2020–21 wine sales deviations. Rows (1), (2) and (4) of Table 9 use the modelled deviation in domestic household consumption shown in columns (1) to (3), multiplied by sales point shares in Table 8, to calculate the contributions shown in columns (4) to (7). Rows (3) and (4) use export volume deviations, as presented above, and row (6), the deviation in national real GDP, to calculate contributions involving users other than households. The add-up of the contributions shown in row (7) of Table 9 aligns quite well with the modelled deviations shown in row (8), with minor differences arising from changing database weights during the simulation. The reason tourism makes a positive contribution to sales is because we assume that domestic consumers substitute domestic tourism for foreign tourism in response to international travel restrictions. Domestic tourism and households (off-premise consumption) make the only positive contributions to sales in 2020–21.

¹¹ <https://www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-tourism-satellite-account/latest-release>

A virtual temporary cessation of tourism exports may have similar negative impacts on total sales as do direct exports. For non-premium wine, from Table 9 (using sales shares shown in Table 8), this is equivalent to a 2.7% decline in sales ($=0.033 \times -82.7\%$). In comparison, the fall in direct exports of 8.1% contributes 4.9% to sales losses ($=0.607 \times -8.1\%$). For commercial-premium wine, the tourism export loss contributes 4.3% to sales losses ($=0.052 \times -82.7\%$) and direct exports 3.0% ($=0.234 \times -12.8\%$). For super-premium wine, tourism exports contribute losses of 2.0% ($=0.024 \times -82.7\%$), and direct exports 3.4% ($=0.106 \times -10.6\%$), to total sales losses. Assuming that a swing from imported to domestic tourism does not compensate fully for a loss in international tourists, sales will not recover fully until tourism exports are restored, since their loss is almost as great as that from direct exports of wine. Restrictions on incoming international tourists are likely to keep wine sales below base, given that this will be the last sales point to recover. Changes in aggregate consumption, reflected in the household contribution in row (4), have a relatively small impact on total sales. This reflects the high export share in total sales.

Domestic grape and wine production remain between 1% and 2% below base at the end of the simulation period (2030). On the supply side, this is because aggregate investment remains below base in all years of the scenario. Consequently, capital persists below base, resulting in below base outputs for all sectors at the national level. On the demand side, the national population has fallen relative to base due to the earlier restrictions on international travel and migration. In turn, aggregate consumption remains below base (Figure 3), weakening household demand for all goods and services relative to base. In addition, as mentioned above, sales arising from tourism exports do not recover fully for several years (Figure 6).

Figure 7 shows the deviation in real producer prices from base (deflated by the GDP price deviation). The grape sectors suffer the largest producer price falls relative to base of the 28 commodities of the database in 2020–21. This reflects the downturn in demand for wine due to the temporary closure of restaurants and tourism activity. Wine grapes are perishable, not internationally tradable and are sold exclusively to the wine sectors, and therefore face very inelastic demand.

4.5 TERM-Wine model's results for Australia's wine regions

The region within Australia suffering the greatest economic losses in 2020–21 is Rest of Victoria, which includes Melbourne (Figure 8). This reflects its longer COVID-19 lockdown than in other regions. Industry composition differences drive little of the differences. The Stage 4 COVID restrictions imposed on Melbourne from July 2020 result in a greater shrinkage than elsewhere. In recovery, the large prolonged deviation of employment below base reflects a decline in net immigration to Melbourne, which has been the highest of all regions in Australia over the decade preceding COVID-19.

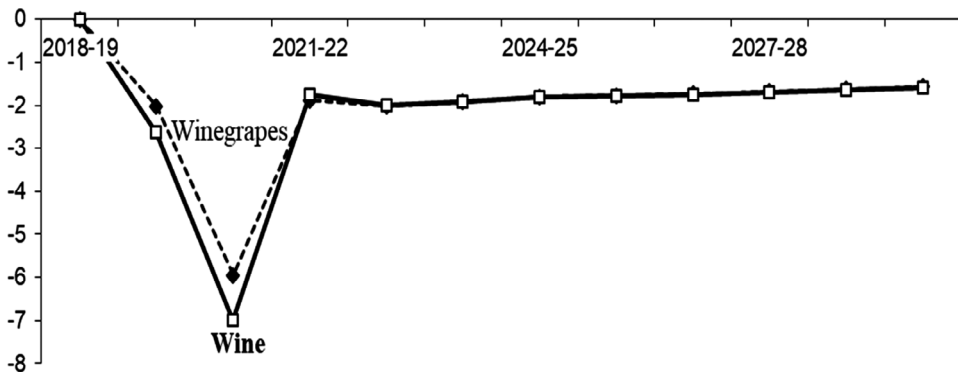


Figure 6 COVID impact on Australian wine sector outputs (% deviation from base).
Source: Authors' TERM-Wine model results.

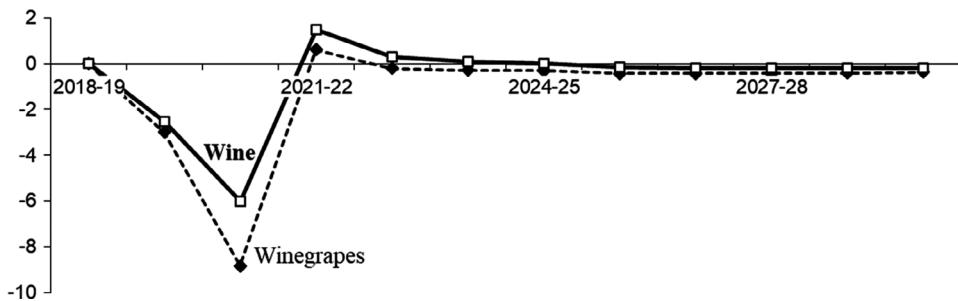


Figure 7 COVID impact on Australia's grape and wine real producer prices (% deviation from base).
Source: Authors' TERM-Wine model results.

The Murray Mallee in South Australia (which includes the Riverland wine region) has the heaviest reliance on grape and wine production in its income base: its fall below base in GDP in 2019–20 and 2020–21 is smaller than for the Rest of Victoria region that includes Melbourne (compare Figures 8 and 9). Murray Mallee's diminished wine sales are significant. However, the severity of lockdown dominates the macro impacts in any region. This means that Murray Mallee's macro deviations from base are proportionally smaller than those in the Melbourne region where the lockdown lasts longer. Moreover, employment moves back somewhat closer to base than in the Melbourne region, reflecting a smaller disruption to labour supply arising from interrupted international travel. That is, baseline net immigration is concentrated in Melbourne and Sydney, and effectively ceases for the duration of international travel restrictions. These have proportionally smaller impacts on other regions.

Table 10 reports on the regional macro impacts, while Figure 10 shows the regional impacts on the volume of wine production and its average price in Australia's key wine regions. Gross winery earnings are projected to be 7–8%

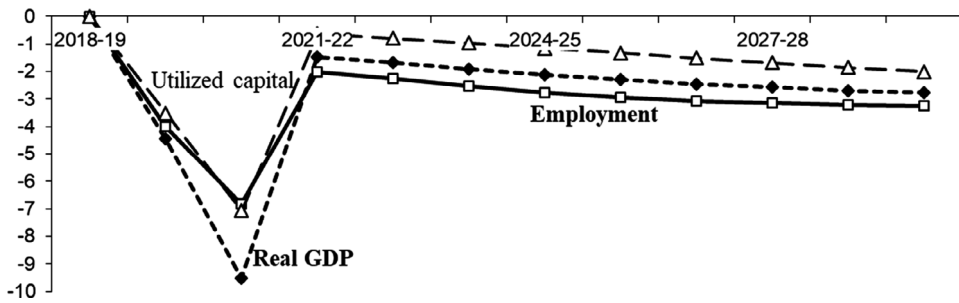


Figure 8 COVID impact on real GDP of Rest of Victoria (inc. Melbourne), income-side (% deviation from base). Source: Authors' TERM-Wine model results.

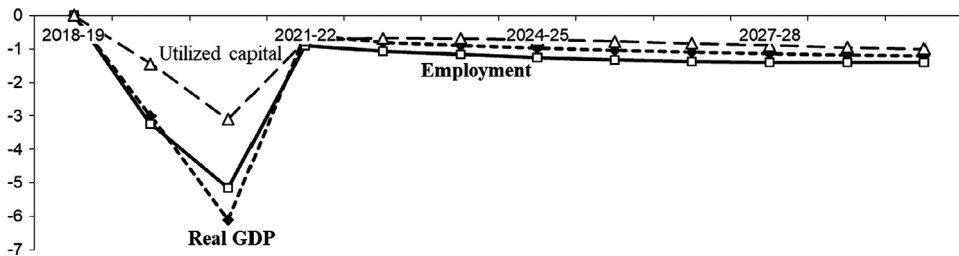


Figure 9 COVID impact on real GDP of SA Murray Mallee, income-side (% deviation from base). Source: Authors' TERM-Wine model results.

lower in 2020–21 than they would have been in the absence of COVID, with the biggest declines in the warmest areas.

5. Lessons learnt: enhancing wine sector resilience to future shocks

This study shows that COVID-19 restrictions and income losses alter the pattern of consumer spending on wine, as wine is both a retail commodity for off-premise consumption and part of a bundle consumed in social activities and travel. In the short term, the industry has followed other retail activities to some extent, with increases in online and phone sales in response to cellar doors and restaurants and pubs temporarily closing or being partly restricted. Overall, increased off-premise consumption is projected in the above modelling to only partly compensate for diminution of sales due to restrictions on social activities, tourism and travel.

The Australian wine industry faced the pandemic in the wake of successive dry years in key winegrape regions that had reduced Australian supply in the 2019 and 2020 vintages. Lower sales in 2020 to some extent alleviated concerns of reduced supply. Around mid-2020, given the high share of Australian exports sold to China (39% by value in 2019–20) and the relatively quick recovery of the Chinese economy from the pandemic, it appeared that

Table 10 Real GDP, employment and utilised capital by region, Australia, 2019–20, 2020–21 and 2029–30 (% deviation from base)

	2019–20			2020–21			2029–30		
	Real GDP	Employment	Capital	Real GDP	Employment	Capital	Real GDP	Employment	Capital
	OthWineNSW	-3.7	-3.7	-2.1	-7.1	-5.2	-4.4	-1.3	-1.5
MDBinNSW	-3.6	-3.7	-2.0	-7.1	-5.1	-4.2	-1.3	-1.5	-1.0
RoNSW	-4.6	-4.2	-3.7	-8.7	-5.2	-7.6	-2.6	-3.1	-1.6
MDBinVic	-3.8	-3.6	-2.5	-7.8	-5.6	-5.1	-1.3	-1.5	-1.0
OthWineVic	-3.9	-3.7	-2.7	-8.0	-5.6	-5.4	-1.4	-1.5	-1.1
RoVic	-4.4	-4.0	-3.5	-9.5	-6.8	-7.1	-2.8	-3.2	-2.0
GranitBltrQld	-3.5	-3.4	-2.2	-6.9	-4.8	-4.5	-1.2	-1.4	-0.9
RoQld	-3.9	-3.6	-2.7	-7.5	-4.8	-5.6	-1.2	-1.4	-0.9
AdelaideReg	-4.0	-3.6	-2.8	-7.8	-4.8	-5.8	-1.3	-1.4	-1.0
SAWineReg	-3.4	-3.5	-1.8	-7.0	-5.6	-3.8	-1.3	-1.5	-1.1
MurMalleeSA	-3.0	-3.2	-1.4	-6.1	-5.1	-3.1	-1.2	-1.4	-1.0
RoSA	-4.1	-3.8	-3.0	-7.9	-4.9	-6.2	-1.2	-1.4	-0.8
WAWineReg	-3.4	-3.4	-2.2	-6.8	-4.9	-4.4	-1.1	-1.4	-0.9
RoWA	-3.4	-3.5	-2.4	-6.7	-4.7	-4.8	-1.0	-1.3	-0.8
Tas	-3.9	-3.6	-2.7	-7.5	-4.9	-5.5	-1.3	-1.5	-1.0
NTACT	-4.2	-3.8	-2.7	-6.8	-3.0	-5.4	-1.1	-1.3	-0.6
AUSTRALIA	-4.2	-3.9	-6.4	-8.1	-5.3	-6.4	-1.9	-2.3	-1.3

Source: Authors' TERM-Wine model results.

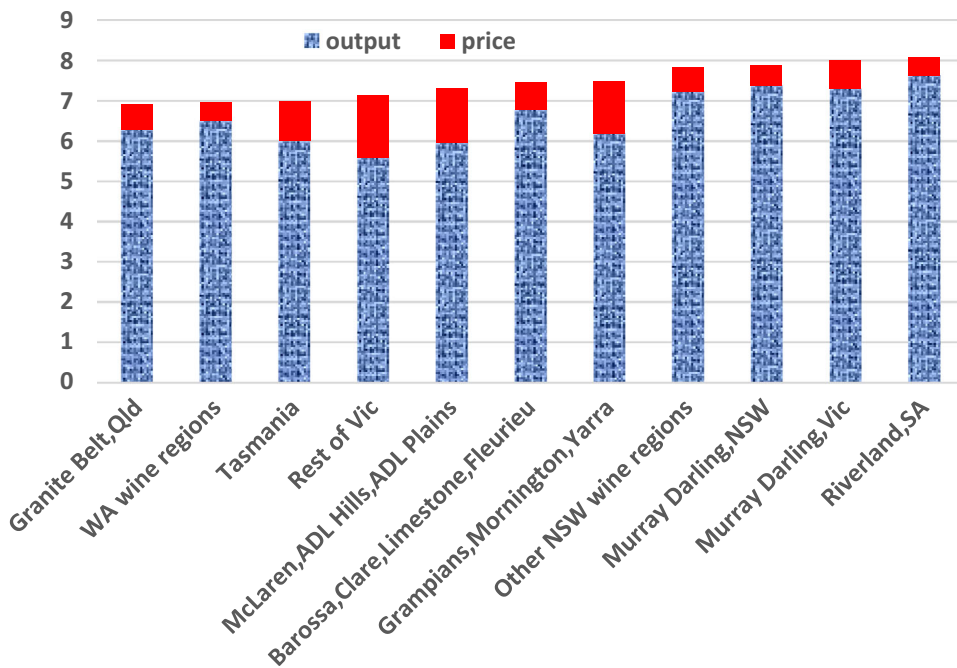


Figure 10 Decline in gross winery earnings (volume plus price falls) due to COVID, by wine region, Australia, 2020–21. Source: Authors' TERM-Wine model results. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/1467-3489.1241)]

the pandemic would not have a marked impact on Australian wine exports. In addition, Australia exports only a small volume of sparkling wine, regarded as the sales segment most severely affected by the pandemic.

Beyond the short-term impact of COVID, a graver concern has emerged in late 2020, namely the imposition of very high temporary tariffs (up to 218%) on China's imports of Australian bottled still wine, pending dumping and subsidy enquiries that are expected to be completed in August 2021—at which time similar-sized anti-dumping and countervail duties may apply for a further five years. The hope is that an amicable solution to this development will be found, but in the meantime many wineries no doubt will seek to diversify their exports to other emerging markets to reduce the risk of this and any future trade disruptions.

Data availability statement

The database and code of the models are not included on the journal's website because they require specialised licensed software (GEMPACK, Horridge et al. (2018)) to access. However, the authors will respond positively to reasonable requests for data.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Supplementary Material